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origin. A very interesting table showing the chemical composition of the ancient igneous rocks of Maryland accompanies this paper.

With regard to the pegmatites, evidence is presented for the belief that very many of them are eruptive; though it is not thought that all will be found to have had that origin. The evidence that they are eruptive is based upon the agreement in composition between the granites and the pegmatites, the greater abundance of the latter near granite masses, their independence as regards the character of the rocks they cross, their relations to the adjoining rock, and the fact that as a rule these pegmatites are neither drusy nor symmetrically banded. The fact that in spite of the essential identity between the composition of the pegmatites and the granites there are certain differences, is interpreted as pointing to somewhat different conditions of formation, in which there was a greater activity of the mineralizing agencies.

The author agreed closely with De Beaumont, Lehmann, and Brögger in his conception of the process of the origin of these pegmatites. They are interpreted "as the products of the residual, and therefore most acid, portion of a granite magma highly charged with water and other mineralizing agents, in a state intermediate between fusion and solution, interjected into fissures and there crystallized in very coarse-grained aggregates, not necessarily through any great slowness of this process, but rather in virtue of the aid to crystallization afforded by the abundance of mineralizers present."

H. F. BAIN.

Sketch of the Geology of the San Francisco Peninsula, by ANDREW C. LAWSON. Fifteenth Ann. Rep. U. S. Geol. Surv., pp. 399–476. Pls. V–XII.

THIS paper is a valuable contribution to the literature of the Pacific coast. The area considered lies between the Pacific Ocean and San Francisco Bay, and extends from the Golden Gate southward about twenty-one miles.

The work done reveals seven formations which, in their geological order, are: (1) Crystalline limestone; (2) Montara granite; (3) The Franciscan series; (4) Sandstone of Tejon (?) age; (5) The Monterey series; (6) The Merced series; (7) The Terrace formations.

The Montara granite is exposed along the Pacific shore about one mile south of Point San Pedro, or about sixteen miles south of the most northern point of the peninsula. At its exposure along the shore line it is overlain by the basal conglomerate of the Franciscan series, but a short distance from shore it becomes the surface rock and covers an elliptical area whose major axis is ten miles, extending in a northwest and southeast direction, and whose minor axis is four miles. That this formation is newer than the crystalline limestone is indicated by the fact that " farther south in the Santa Cruz range, the same granite is found in irruptive contact with pre-existing terranes among which crystalline limestone or marble is prominent," and also by the fact that a mass of marble was found embedded in the granite within the area considered.

The petrographic character of the Montara granite leads to the conclusion that it cooled as a batholite. The mantle, which consisted in part of the crystalline limestone was almost entirely removed before the Franciscan series were deposited, which in turn were removed before the Tejon-like sandstones were laid down.

The Franciscan series occupy the greater part of the peninsula, and are separated by the Merced Valley into a northern and a southern area. Petrographically the series are divided into (1) A basal formation; (2) The San Francisco sandstone; (3) Foraminiferal limestone; (4) Radiolarian cherts; (5) Volcanic rocks. Of these the most important are the San Francisco sandstone and the Radiolarian cherts.

The San Francisco sandstone is that of the early writers. It forms the bulk of the sedimentary rock of the series. Its original color is a greenish or bluish gray, but it easily weathers to a yellowish brown. In the field it presents a massive aspect "due to the thickness of the beds and the obscurity of the bedding planes."

The Foraminiferal limestone is described as having "a fairly constant petrographic character throughout the terrane, although it is found at more than one horizon." It is generally traversed by two sets of veins — calcitic and siliceous. The latter are often parallel to the bedding of the limestone, and may be contemporaneous with it. The limestone itself is thought to be a chemical precipitate.

The Radiolarian cherts are of a dull reddish-brown color, are several hundred feet thick, composed of sheets of chert from one to four inches thick alternating with partings of shale, and occur locally in lens-like masses. Petrographically they occur as true jaspers, as rocks of a flinty or hornstone character, as rocks that are easily scratched with a knife, and sometimes as quartz rock which resembles vein quartz. They vary from those which are amorphous silica to those which are chiefly holocrystalline aggregates of quartz granules. The mineralogical character of the amorphous silica is doubtful. It is perfectly isotropic, but contains a less amount of water and is harder than opal.

Concerning the origin of the Radiolarian cherts, Professor Lawson advances the theory that they are chemical precipitates from springs, and supports the theory by the fact that they occur locally and in lens-like masses. In working over the field in San Francisco and vicinity, it has seemed to the present writer that these rocks were once widespread. This is indicated by the small fragments of chert almost everywhere found on the surface. Their present local occurrence is not remarkable when it is remembered that they have suffered at least two periods of erosion — that preceding the deposition of the Merced series, and the present one. There is also some evidence of an unconformity between the lower portion of this series and the bed of sandstone which separates it into two parts.

The serpentine of the area occurs with the Franciscan series, and is in three tracts extending from northwest to southeast parallel with the strike of the rocks. One of these tracts is north of the Merced Valley, and two of them south. That on the north side occurs in three large masses which are described as the Presidio laccolite, the Potrero laccolite, and Hunters Point laccolite. These are probably expansions in a dike of serpentine which extends from Fort Point to Hunters Point, a distance of about ten miles. They are in places one and one-half miles wide, and reach a thickness of 500 feet. Both the Presidio mass and the Potrero mass consist of two lenses of serpentine separated by sandstone.

The writer calls attention to the great number of masses of "medium-grained, dark, greenish gray rock" in the serpentine of Potrero and Hunters Point. These have been shown to belong to the hypersthene diabases, and in their more altered forms to the epidiorites, and are thought to be inclusions in the serpentine.

The present writer is not familiar with either of the two serpentine tracts on the south side of Merced Valley, but they are described as in all essentials similar to that on the north side.

Professor Lawson finds nothing from either microscopic study or field observations to support the theory that this serpentine has originated from sandstone, but concludes that "the various conditions and aspects assumed by the rock are functions of a process of chemical alteration from peridotite or pyroxenite and a mechanical disintegration of the rock thus altered."

The rocks of the Merced series rest unconformably upon the Franciscan series, and occur in two areas, one on either side of Montara Mountain. The series consists chiefly of soft sandstone. There are, however, among the series, hard shell beds firmly cemented, and soft shell beds, uncemented; hard beds of gravel, lignitic beds, and a bed of volcanic ash. The northern of the two areas dips to the northeast, and is exposed along the beach for a distance of 20,000 feet. It is 5800 feet thick, and is the heaviest Pliocene deposit known in North America.

The most marked structural feature of the region consists of two fault blocks, both tilted to the northeast, and designated as the San Bruno block and the Montara block. It is this tilting of the Montara block that gives the Merced series its constant dip to the northeast.

That the San Bruno block is older than the Montara block is proved by the fact that the Merced series has all been removed from the former, as well as by the fact that its topography is more mature than the latter.

Two cycles of erosion are indicated on the San Bruno block — an early one which is manifested only above an altitude of 300 or 400 feet, and a later one which has modified the old topography. The modification of the old topography has been effected in two ways. The first is that due to atmospheric and stream agencies, the second to "destructive and constructive shore action at the various stages of the uplift." The crest of San Bruno Mountain is thought to be due to the same cause which determined the 1200-foot terrace on the higher Montara block; and the 750-foot terrace on San Bruno mountain is doubtless due to the same shore line that formed the 700-foot terrace on the Montara block.

On the Montara block there is only the later cycle of erosion manifested. During this time there were formed the two terraces above mentioned. These are well marked on the northeast slope, and less so on the southwest slope.

The consequent streams on the northeast slope of the Montara block which came into existence on its emergence from the ocean, became superimposed streams on reaching the hard terranes beneath the soft Merced series. Later, as a result of the longitudinal faulting, these were changed into subsequent streams. As these developed, the superimposed consequent streams became atrophied, leaving only the lower part of the San Mateo Creek. "The remarkably straight valley of Crystal Spring and San Andreas is a magnificent example of a subsequent drainage system extending laterally along a fault in opposite directions normal to the original consequent drainage." Other excellent examples of captured and superimposed streams are mentioned.

Lake Merced, though in a structural valley, is considered a drowned valley of stream erosion. The bottom of the lake is ten feet below sea level, which demonstrates its recent submergence. Its access to the ocean was cut off by sand dunes which dammed up its channel till the water stood ten feet above tide.

The contrast between the ocean shore-line and that of the bay is noted. The former presents steep cliffs and sandy beaches due to the vigorous action of the waves, while the latter has a tidal marsh, in places some miles wide. This marsh may be due to the deposition of material from the bay water during the rainy season. The fact that the tidal marsh is perfectly level and the tidal streams reach back to its rear, indicates that there has been no very recent uplift. On the other hand there may have been a slow subsidence, during which the rate of deposition was equal to the subsidence.

The colored relief map accompanying the paper is worthy of special note for its elegance and effectiveness.

A. H. PURDUE.